

Mature Willow Transplants (MWT)



Materials:

- 90 willow clumps
- Shovels
- Loppers

Transplanting willow clumps is a bioengineering technique that can be used when large stands of willows are available within the project site area. This technique involves the harvest of an entire live willow clump including the above ground stems and below ground roots. The willow stem collar (where the stem meets the root material) does not need to be at the soil surface or slightly below the soils surface in order for the plant to survive. This allows for the transplanted willow to be “countersunk” lower into the bank so the lower $\frac{1}{2}$ to $\frac{1}{4}$ of the root ball is in saturated or wet soils. Because the willow clumps can be countersunk into a bank, higher and drier banks can be treated with this method than with many other methods.

Willow Transplants and Planting Methods

The project engineer and/or vegetation specialist will flag the transplant locations and holes will be pre-dug prior to moving the transplant willows. The average spacing between transplanted clumps will be approximately 20 feet, which is consistent with the spacing of what was observed to occur naturally. To achieve this spacing the first willow transplant will be located at the area of critical bank erosion and the locations of the other willow transplants (or vertical bundles) determined by measuring up and downstream from that location along the banks needing treatment. Transplants will be installed approximately 2 feet from the deepest part of the undercut bank, or the top of bank if it is not undercut. This setbank will give the willow a chance to establish prior to being subjected to erosive forces during high runoff. The holes will be dug to a depth **just above the standing water table**. Holes should not be dug into the low flow water table. The root mass of the clump needs to be in the saturated zone and not in the standing water zone. The hole will be dug 25% larger than the diameter of the clump (using the excavator bucket as a guide). Where the willows are “countersunk” the plant should have at least 4 to 5 feet of the willow stems above the ground following planting.

The vegetation specialist will identify and flag suitable willows for transplanting. Plants need to be dormant (early spring or fall) and soils moist prior to digging. Selected willows plants should be young and vigorous, about 8 to 20 feet tall, and about the diameter of the backhoe or excavator bucket. The willows selected for transplanting should be at least 15 to 20 feet apart and not harvested from critical locations prone to future erosion. The excavator will transport the soil from the pre-dug holes to the area where the transplanted willow will be harvested. This soil will be used to backfill the holes.

The willows will be transplanted by digging straight down and under the willow clump root mass. Start the hole about 18 inches away from the stem and dig down about the depth of the bucket (approximately 2 to 3 feet).

Dig the clump and travel to the planting site with it in the bucket. Keep as much soil as possible around the root mass. Clumps will be planted within 2 hours of digging. "Mud in" (i.e. after planting water) the willow clumps to eliminate air pockets around the root mass. Use the excavator bucket to scoop water from the stream and pour over the willow clump to eliminate air pockets around the root mass. More soil may be needed as soil settles in the hole and around the roots. Continue to add water and soil until the soil is packed securely around the base of the willow plant.

The next to last step is to remove approximately one-third of the willow tops using loppers. This decreased the amount of stem that the reduced root mass will have to support. It also stimulates a dense regrowth of stems and leaves that will speed up the photosynthesis process to grow additional roots, stems and leaves and store energy in the root mass.

The final step is general clean up of the planting area. Hand work may include raking to smooth soils and reduce surface roughness. All disturbed soils will be reseeded including where the willow clumps were harvested, planted and equipment travel areas.



For the McDowell project, planting holes will be pre-dug and the willow will be placed directly into the hole rather than temporarily placed along side the hole.

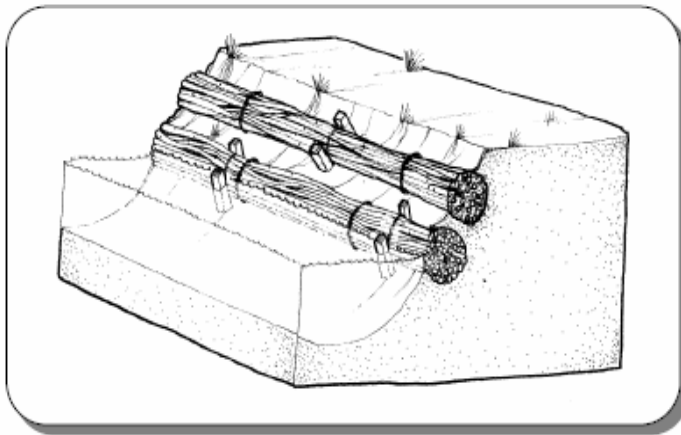


Mudding-in or watering the willow after planting. This may need to be done more than once to remove air pockets around roots.



Willow clump after backfilling and watering. Soils are firmly around the plant base.

Willow Wattles (WW)



Materials:

- Willow cuttings (8 to 10 ft long)
- Shovels
- Poly-twine
- Wooden stakes
- Wire

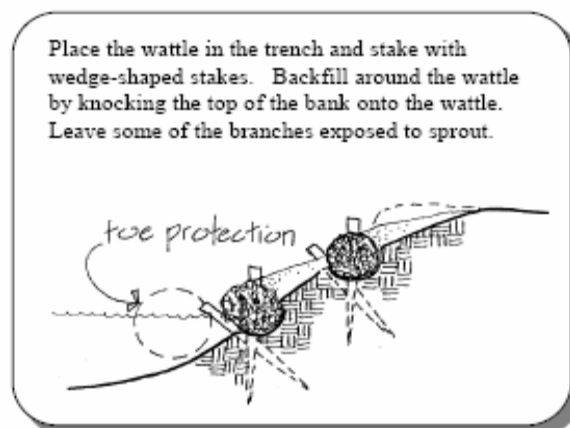
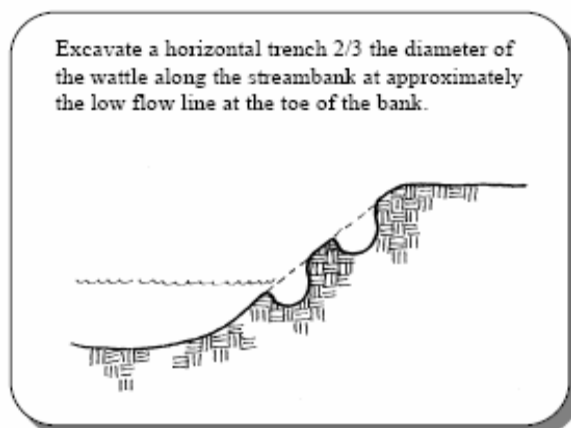
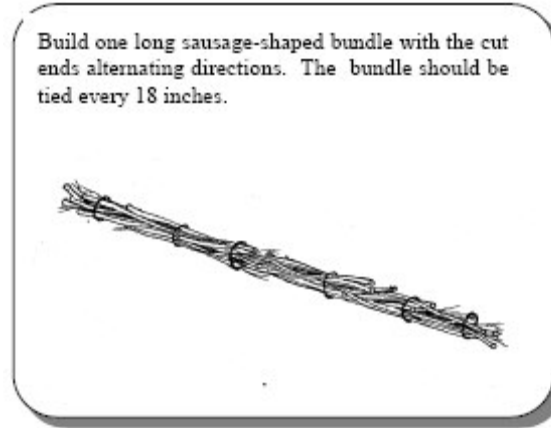
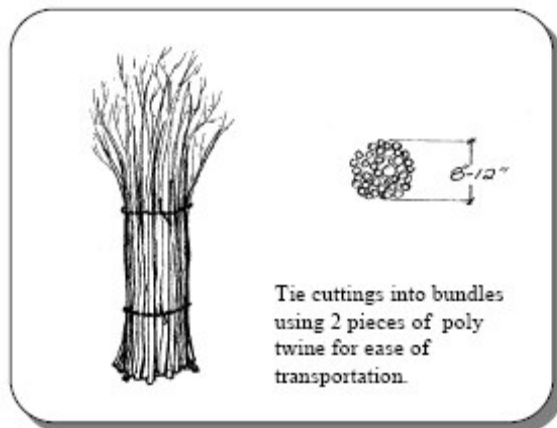
Willow wattles (*Salix* spp.) are long bundles of live cuttings tied together and inserted into a shallow trench dug into the streambank. This is a good technique with cuttings to break up slope length, build banks and minimize erosion with vegetation cover. Approximately 1,415 linear feet of the project area will receive this treatment. The project engineer or vegetation specialist will identify and mark the banks receiving this treatment.

Installation

The goal is to build one long sausage-shaped bundle with the cut ends in alternating directions. Drawings of wattle construction and installation are provided on the following page. Wattles will be prepared from dormant cuttings that are at least a ½ inch in diameter or larger, to ensure an adequate supply of stored energy for rooting. Each wattle will contain approximately 10 cuttings per bundle (8 to 12 inches in diameter) with the terminal or butt ends of the cuttings placed in opposite directions. Wattles will be constructed on-site due to the difficulty in transporting them once they are assembled. The wattle will be tied together every 18 inches.

A horizontal trench (parallel to the river) 2/3 the diameter of the wattle will be excavated / hand-dug into the streambank at approximately the low flow line. Grade for the wattle trenches will be determined using an Abney level or similar device and will follow the bank contour. The wattle will be placed in the trench overlapping the twine ends and staked every 3 to 4 feet with 24 to 42 inch wooden stakes, willow stakes may be used as an alternative. Willow stakes may be made of live willow cuttings greater than 1½ inches in diameter. Place stakes on both sides of the wattle and wire across the bundle. Backfill around the wattle by pulling soil from the bank on top of and into the wattle, making sure to work soil into the branches. The upstream wattle end will be keyed into the bank by deepening the trench and bending the wattle end into the bank and staking it there. The length of the wattles will vary depending upon the bank length requiring treatment.

All disturbed soil will be reseeded immediately following installation.



(Bentrup and Hoag 1998)

Only one wattle will be used and installed at the low flow line. There is normally not enough moisture near the mid to upper bank to establish another wattle, however willow cuttings may be used behind the wattle since the cuttings would reach the low flow water table.

Bentrup G. and Chris J. Hoag. 1998. The Practical Streambank Bioengineering Guide. Interagency Riparian/Wetland Development Project. USDA-Natural Resources Conservation Service. Plant Materials Center. Aberdeen, Idaho.

Brush Layering (BL)



Materials:

- Willow cuttings (4 to 5 ft. long)
- Shovels

This technique uses willow cuttings in buried trenches along the slope of an eroding streambank. This willow “terrace” is used to reduce the length of slope of the streambank (see figures on following page). The cuttings will sprout and root, stabilizing the streambank with a dense matrix of roots and stems. Approximately 562 linear feet of the project area will receive this treatment. In the McDowell Reach brush layering is most commonly recommended for short portions of banks that have been scalloped, such as that shown in photograph above. The project engineer or vegetation specialist will identify and mark the specific portions of banks receiving this treatment.

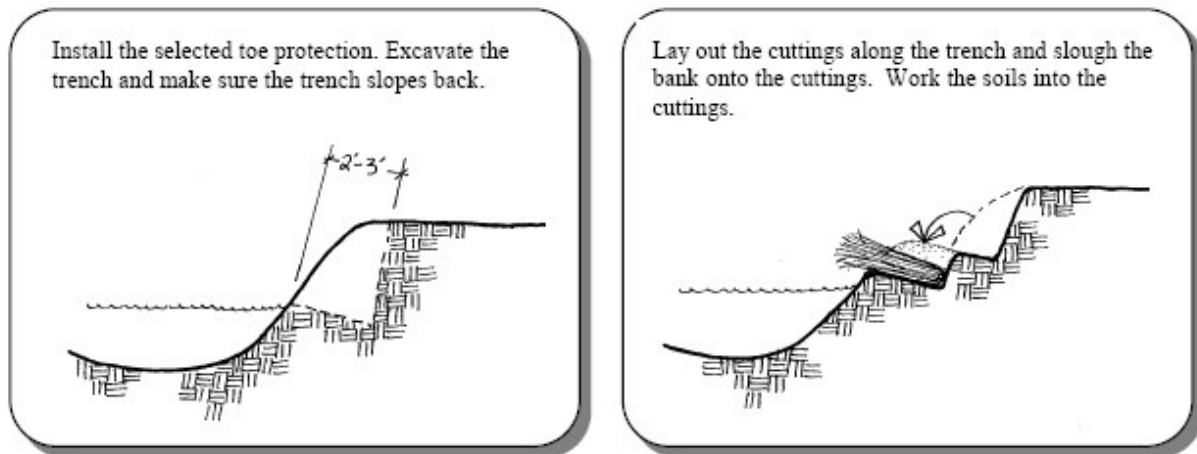
Installation

Willow cuttings will be harvested from live, dormant willows and be at least a ½ inch diameter or larger to ensure an adequate supply of stored energy for rooting.

A horizontal trench will be excavated into the scalloped area of the streambank; excavated material is saved for backfilling. The surface of the trench will be sloped 10 to 20 degrees such that the outside edge (stream side) is higher than the inside (bank side). The trench will be approximately 2 to 3 feet deep and the bank side, deep enough so that willow cuttings can be inserted into the low flow water table.

Willow cuttings will be placed side by side (1 stem per inch) inside the trench with the basal cut ends reach the water at the bottom of the trench. Cover the cuttings with soil excavated from the trench and pack the soil into the cuttings, water the soil when back filling. The cuttings should extend no more than 12 to 18 inches from the bank to prevent them from being ripped out during high flows. Trim off the excess. Only 1 layer of cuttings is planned for this project, though more layers could be installed as needed.

All disturbed soil will be reseeded immediately following installation.



Bentrup G. and Chris Hoag, May 1998.

Bentrup G. and Chris J. Hoag. 1998. The Practical Streambank Bioengineering Guide. Interagency Riparian/Wetland Development Project. USDA-Natural Resources Conservation Service. Plant Materials Center. Aberdeen, Idaho.

Sedge Mats (SM)



(Chris Hoag using willow cuttings to pin a sedge mat)

Materials:

- Willow cuttings (4 to 6 ft. long)
- Loppers
- Approximately 3,160 sq ft of sedge mats in 11 different areas. (project engineer will determine harvest locations nearest installation sites).

The use of on-site harvested wetland sedge mats will be used on selected areas along the river edge. The sedge mats will be harvested and placed using an excavator. Willow cuttings will be placed around the perimeter of the mats to aid in holding the mats in place. The mats provide rapid establishment and diversity of plant cover, while the willows gradually restore the appearance and function of the shrub community providing bank stability, shade, cover and structural diversity along the stream bank of the channel. Sedge mats aid in reducing the influence of nutrients from adjacent upland habitats, are tolerant of fluctuating hydrologic conditions and immediately stabilizes erosion prone areas.

Harvesting the Sod and Pinning

There are numerous areas within the project boundaries that have sedge vegetation cover. Specific sedge source (harvest) areas will be generally inconspicuous areas, that are slightly lower in elevation from the adjacent lands. Harvest sites must be accessible to equipment (excavator/backhoe). No more than 50% of an existing wetland will be harvested and will be harvested in a 'patchy' fashion so that runoff from the harvested area will first have to pass through vegetated areas before entering the river and to increase the rate at which the harvested areas revegetate.

Potential sedge mat source areas contain a mixture of sedge species (OBL, FACW, or FAC) that are suitable to a variety of hydrologic conditions; ranging from seasonally flooded to saturated soil conditions. The species type and its hydrologic condition (saturated, ponded, etc.) will be noted during harvest so that it can be planted at a spot on the bank with similar hydrologic conditions.

The project engineer/vegetation specialist will identify and mark (both on the map and in the field) the areas requiring sedge mats. Harvest areas will then be identified in near proximity to the placement area. The maximum travel distance for the equipment (excavator or backhoe) is 150 to 200 ft. Prior to harvesting, the planting site should be prepared, usually by excavating the site to accommodate the mass of soil and roots that will be placed there.

The equipment bucket should be no less than 2 feet wide to minimize the number of trips between the sedge source and the planting location. The salvaged mats must be 6 to 12 inches thick and contain a substantial amount of the root mass.

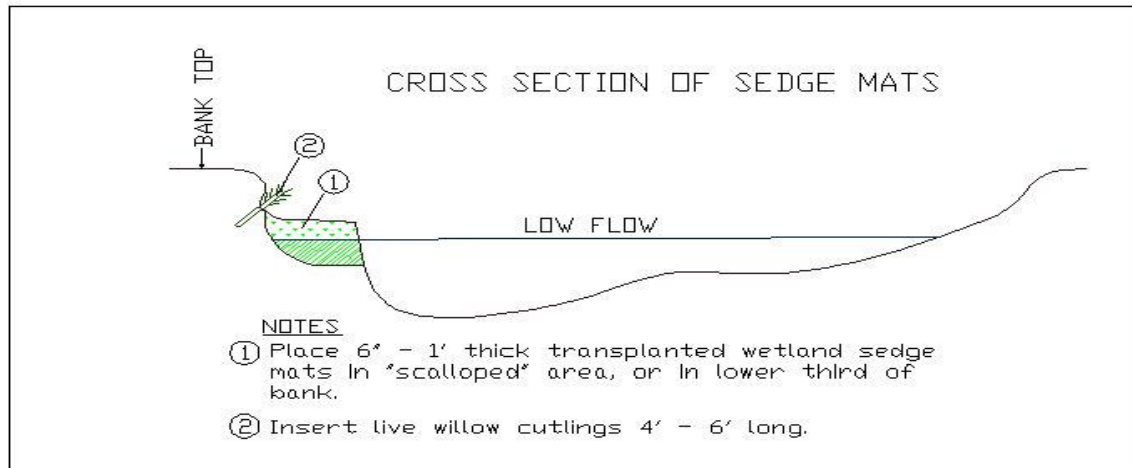
Once the mats are placed, willow cuttings ($\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter or larger depending upon the species) will be inserted around the sedge perimeter to secure the mat. Cuttings will be placed on 1-foot centers around the entire perimeter of the mats.

The optimum time for harvesting and placement of the sedge mats is during the growing season. However fall or early spring placement will be acceptable. The sedge mats must be placed within 24 hours of harvest. At no time will the sedge mats will allowed to dry out or the roots freeze. Efforts will be taken to ensure the root mass and plant material are not desiccated during salvage and transport.

The willow cuttings can be installed using waterjet stingers (see NRCS Technical Note No. 39), planting bars, excavator mounted dibble bars, or by pushing the cuttings into moist soil by hand. The planting depth and location will determine the planting methods.

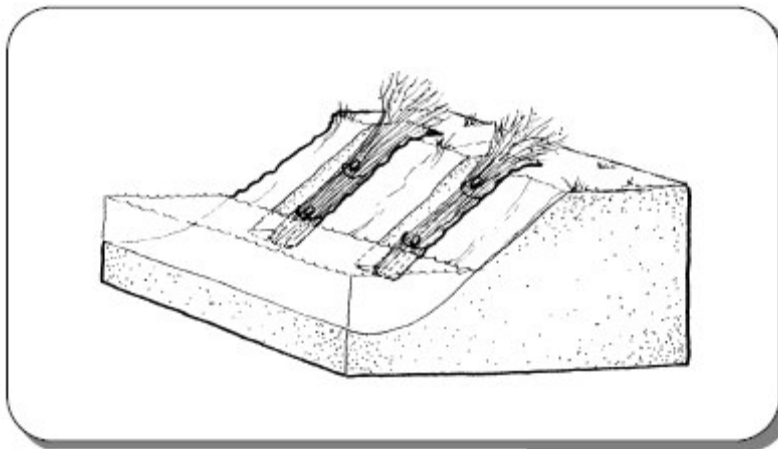
All restoration areas to receive sedge mats will be identified, flagged or marked prior to the arrival of the equipment.

All disturbed areas will be reseeded following construction activities.



An example of where sedge mats will be used.

Willow Bundles on Sculpted Banks (SB)



(Bentrup and Hoag 1998)

Materials:

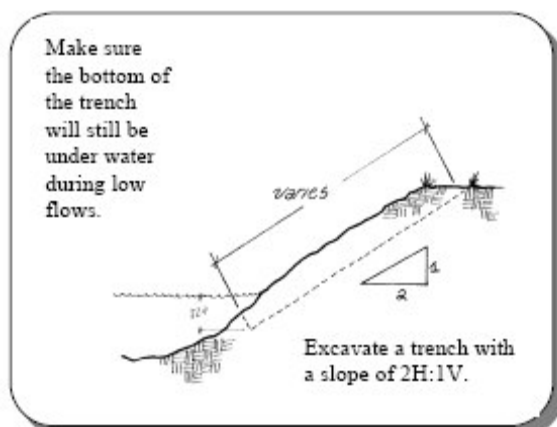
- Willow cuttings (5 to 7 ft. long)
- Poly-twine
- Shovels
- Willow cuttings for toe (4 ft-long)
- Wooden stakes

This technique uses bundles of willow cuttings (*Salix* spp.) in vertical trenches along an eroding streambank. The willow cuttings will sprout and root stabilizing the bank with a dense network of roots and above ground stems.

The cuttings will be ½ inch in diameter or larger to ensure an adequate supply of stored energy for rooting. Include a mixture of various species and sizes. Cuttings will be tied into bundles ranging from 3 to 18 inches in diameter depending upon use and position with all the growing tips orientated up. The terminal bud needs to be removed so that stem energy will be re-sprouted to the lateral buds for more efficient root and stem sprouting.

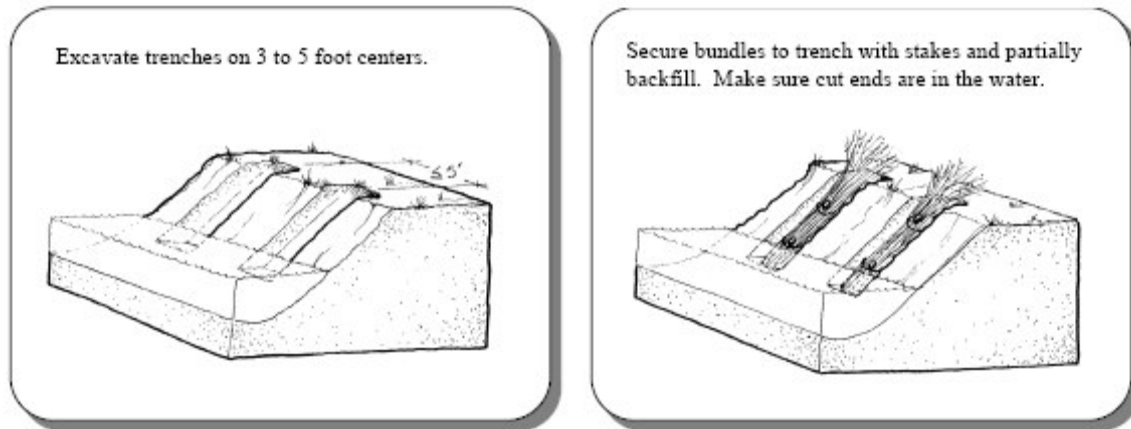
Following bank reshaping, narrow vertical trenches will be excavated with a slope of 2:1 or more in the streambank. Typically the trenches are approximately 10 to 12- inches wide and long enough where the bottom of the trench will be under water during low flows.

Trenches should be excavated on roughly 3 ft centers. Place the bundles in the trenches with the cut ends in the water and then secure them to the bank with wooded stakes. Partially backfill with soil around the bundles.



It is important to make sure that the endpoints of the bundles are securely staked to prevent flows from getting behind the bundles.

(Bentrup and Hoag 1998)



Salvaged sod removed during the bank reshaping will be placed at the toe as well as willow cuttings to provide toe protection.

All disturbed soil along the bank slope and top of bank will be reseeded.



Photo of a completed bank receiving willow bundles and willow cuttings at the toe.

Bentrop G. and Chris J. Hoag. 1998. The Practical Streambank Bioengineering Guide. Interagency Riparian/Wetland Development Project. USDA-Natural Resources Conservation Service. Plant Materials Center. Aberdeen, Idaho.

Vertical Bundles (VB)



Materials

- Willow cuttings (5 to 7 ft. long)
- Create 715 holes (5 stems per hole)
- Skid Steer with 12 inch auger
- Shovels
- Wooden stakes

An example of a bank where vertical bundles will be used.

This technique uses bundles of willow cuttings (*Salix* spp.) in a vertical hole created at incremental spacing along the bank top. Each hole will receive 5 willow cuttings and this number increases the probability of success and provides more roots more rapidly than a single cutting. Rows of vertical bundles extend away from the channel will be installed at the apex of the meander bend to provide both short and long term stability. Individual bundles can be installed wherever additional support or shade is needed.

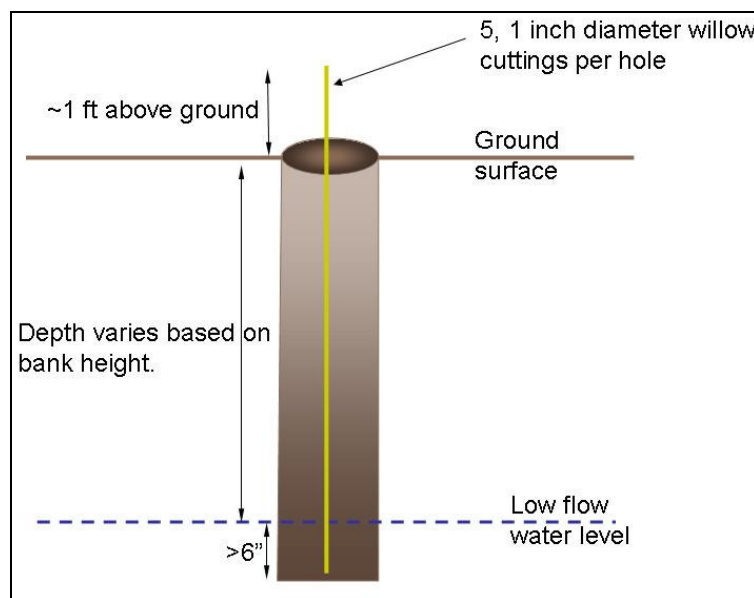
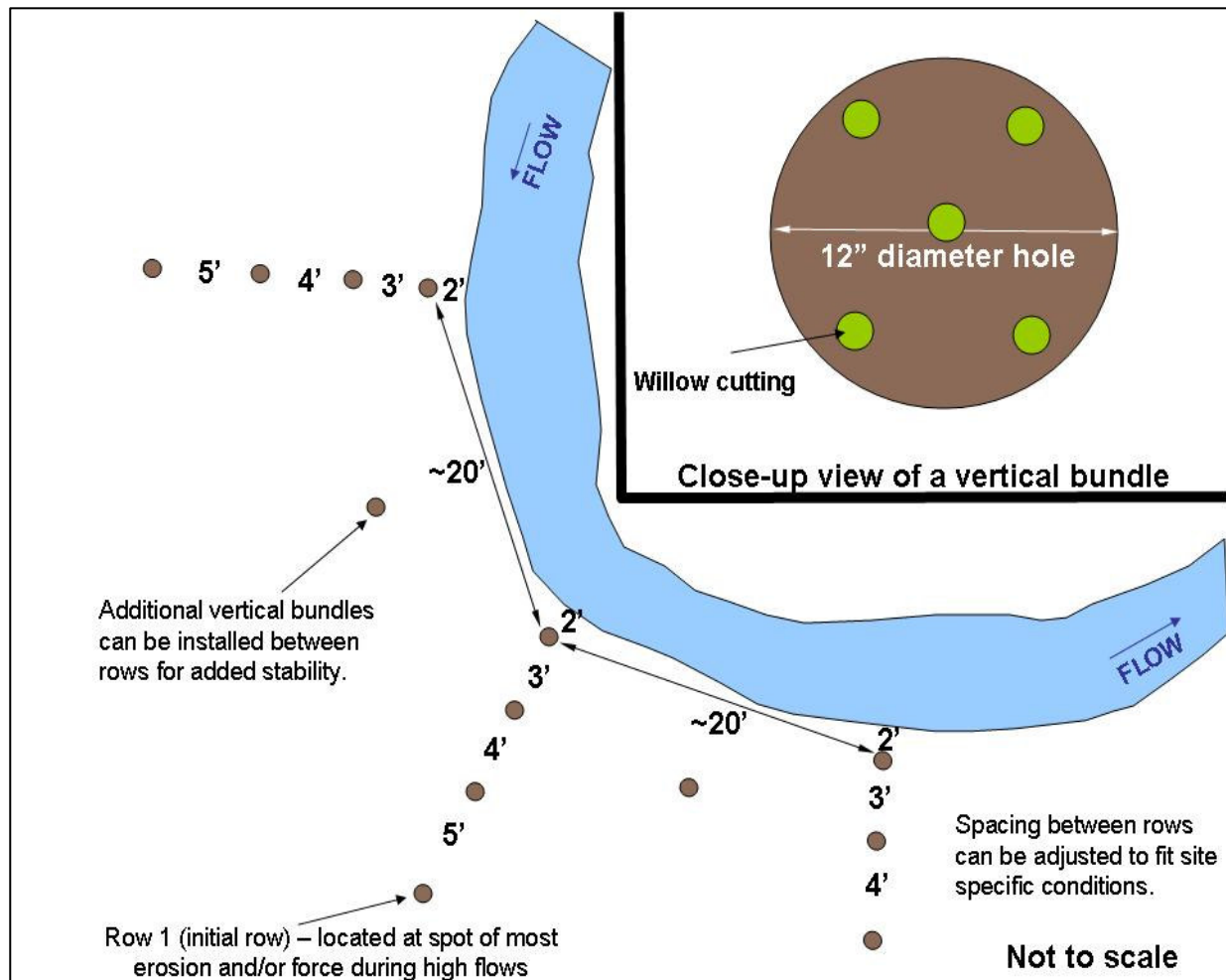
A skid steer will be used to create a hole approximately 12 inches or smaller in diameter, extending into the low water table no less than 6 inches. Five willow cuttings will be staged at each hole, and the cuttings will be placed in the hole as shown on page 2. The bottom of the cuttings will be inserted 6 to 8 inches into the low water table. The hole will then be back filled by hand, the soil compacted around each cuttings, and watered in as needed.

The cuttings will be ½ inch in diameter or larger to ensure an adequate supply of stored energy for rooting.

The spacing for the holes starts at 2 feet from the top of bank, then extends to 3 feet, 4 feet and 5 feet (see diagram on page 2). The initial row will be located at the spot of most erosion and/or force during high flows. The distance between the vertical rows is approximately 20 feet. The skid steer will work from the channel bank toward the floodplain.

The project engineer will identify the areas to receive this treatment. The area will be flagged and the correct number of cuttings provided for each area.

All restoration areas disturbed soils will be reseeded following planting.



Pinning Bank Sloughs (PBS)



Materials:

- Willow stakes/cuttings (4 to 5 ft long)
- Loppers
- Waterjet Stinger (see NRCS Technical Note No. 39)

(Example of where pinning a bank slough will be used).

Banks which contain a sufficient cover of sedges and / or rushes (approximately 15% cover) often fold over. The approach for stabilizing this type of bank is to pin the folded over bank in place using willow stakes. This method is experimental.

Installation

The willow stakes will be 2 inch diameter or larger. The larger diameter cuttings have more energy and stored reserves than smaller diameter cuttings. The larger diameter willow stakes will contribute to bank stability.

Cutting length will be determined by the bank height and depth to the mid-summer water table. At least 6 to 8 inches of the cuttings will be in the mid-summer water table, 3 to 4 buds are above the ground, or no less than ½ of the total length of the cutting is in the ground.

Willow stakes will be inserted on 1 ft centers, in slightly staggered rows to adequately secure the vegetation and root mass.

Willow stakes can be installed using waterjet stingers (see NRCS Technical Note No. 39), or by pushing the cuttings into moist soil by hand. The cutting planting depth and location will determine which planting method is used. The key planting tip for cuttings is to have good contact between the cutting and the soil so that there are no air pockets (voids) around the cutting. One advantage of using a waterjet stinger is that it uses water to create a planting hole which helps removes air pockets around the cuttings because the planting holes are saturated and soil material settles around the stem in a manner conducive to promoting root growth.

All areas to receive pinning will be identified, flagged or marked prior to planting to ensure the proper location and quantity at each bank.

Willow Cuttings (WC)



(Photo shows cuttings and geotextile fabric along the lower bank)

Materials:

- Willow cuttings
- Willow cutting lengths will vary and will be determined by project engineer or vegetation specialist prior to harvesting.
- Loppers
- Hand pruners
- Rotary saws
- ATV
- 2 Waterjet Stingers (see NRCS Technical Note No. 39)
- Poly-twine

Willow cuttings are an unrooted dormant woody stem inserted directly into the ground to root. The use of cuttings provides several advantages. The larger diameter and length of the cutting provide a competitive advantage over herbaceous and weed species, and often cuttings provide the only means to reach moisture at deeper depths, such as on steep streambanks or on the upper portions of banks. The cuttings of many willow species are successful if harvested and planted properly (as outline below) due to a high concentration of root primordial located through the length of the stems.

Only certain willow species can generate readily from cuttings. Sandbar willow (*Salix exigua*), Bebb willow (*Salix bebbiana*), Booth's willow (*Salix boothii*), Drummond willow (*Salix drummondiana*) and yellow willow (*Salix lutea*) root quickly and freely (Platts et al. 1987). Cuttings of Geyer willow (*Salix geyerana*) are generally less successful than these species, though larger diameter (>1 inch) and/or longer cuttings of Geyer willow are generally successful and can be used where appropriate. Geyer willow cuttings can also be used in areas or treatments requiring higher planting densities.

Harvesting Cuttings

Cuttings to be utilized for live planting will be harvested from stands located near the project site that are healthy stands free of damage from insects or disease. Cuttings will be collected during the dormant season to ensure the highest success rate. No more than 2/3 of the total branches on any willow shrub (i.e., clump) may be harvested for use as live stakes unless authorized by the property owner. Hand pruners or rotary saws may be utilized for willow cutting harvests. Willow cuttings are cut at an angle using a sharp tool that leaves a clean (not ragged) cut.

The cuttings will be ½ to 1 inch in diameter, or larger, depending upon the species. The larger diameter cuttings have more energy and stored reserves than smaller diameter cuttings, and so are generally more viable and hardy.

Cutting length will be determined by the planting location and depth to the mid-summer water table. At least 6 to 8 inches of the cuttings are in the mid-summer water table, 3 to 4 buds are above the ground or no less than ½ of the total length of the cuttings is in the ground.

Cuttings used for the vertical bundles, willow wattles and brush layering do not require removal of the terminal twigs and branches. All other cuttings will require removal of all branches, twigs and the terminal buds. Geyer willow can be harvested to be mixed in with the other willow species to represent approximately 25% of the species in the vertical bundles, willow wattles and brush layering.

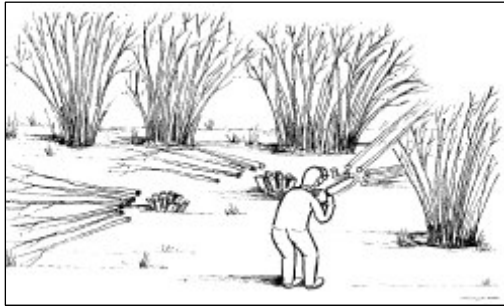
Immediately following harvesting, cuttings will be bundled by species with the terminal ends together. All willow cuttings will be bundled in groups of 10, 25 or 50 for ease of counting and distribution. Based on the construction/planting schedule, the cuttings may either be planted in the fall or stored in a cold storage facility for later planting in the spring, early summer. The cold storage facility will be maintained at temperatures between 35 and 50 degrees Fahrenheit. When being stored cuttings will not be exposed to the sun or drying conditions.

Planting Cuttings

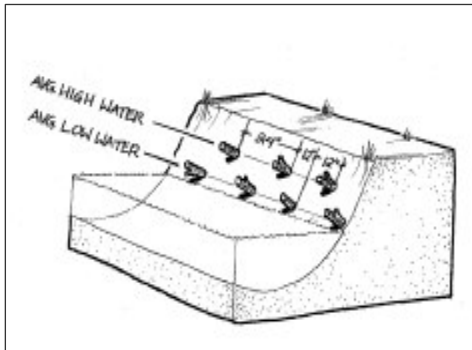
Diagrams of planting willow cuttings are found on the following page. Spring plantings are generally more successful than fall plantings. Late summer plantings of willows are unacceptable. Prior to a spring planting, the cuttings will be soaked for 5 to 7 days in order to release anti-rooting hormones in the bark of the willows, initiate root growth within the inner bark layer, and to improve stem water content. Soaking is not recommended for a fall planting. When being soaked the entire cutting will be covered with water. Soaking can be accomplished in a ditch, stream, pond or other body of flowing water that is deep enough to completely cover the bundled cuttings. Flow conditions and beaver use of the area are considerations when selecting soaking sites.

Willow cuttings can be installed using waterjet stingers (see NRCS Technical Note No. 39), tractor-mounted soil augers, planting bars, excavator mounted dibble bars, or by pushing the cuttings into moist soil by hand. The planting depth and location will determine the planting methods. The key to success is to have good contact between the cuttings and the soil with no air pockets (voids) around the cuttings. One advantage of using a waterjet stinger is that it uses water to create a planting hole which saturates it and soil material settles around the stem in a manner conducive to promoting root growth. For all other planting methods that do not use water, each hole will require packing soil around the cuttings to prevent air pockets and filling the hole with water and adding soil to make a mud slurry to remove air. On the McDowell Reach the majority of the willow cuttings will be planted using a waterjet stinger.

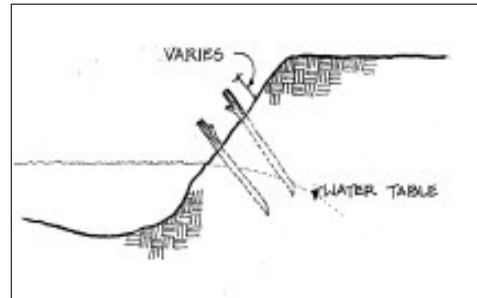
All areas to receive willow cuttings treatment will be identified, flagged or marked prior to planting to ensure the proper installation and quantity at each bank.



Thin no more than 2/3 of each total plant.



Cuttings will typically be planted on staggered rows to cover the range in fluctuating water levels.



The cutting must extend at least 6 inches into the permanent water table to ensure adequate moisture for sprouting. At least $\frac{1}{2}$ to $\frac{2}{3}$ of the cutting must be below ground to prevent the cuttings from being damaged during high flows and to prevent dessication.

Figures are from Bentrup and Hoag (1998).

Platts, W. S. et al. 1987. Methods for evaluating riparian habitats with application to management. General Technical Report INT-221. USDA Forest Service Intermountain Research Station.

Containerized Willow Tubelings for Floodplain Plantings



A properly planted tubeling.

Materials:

- ~15,000 10-cubic inch willows
- Hoedads
- Planting bags
- ATV to stage plants

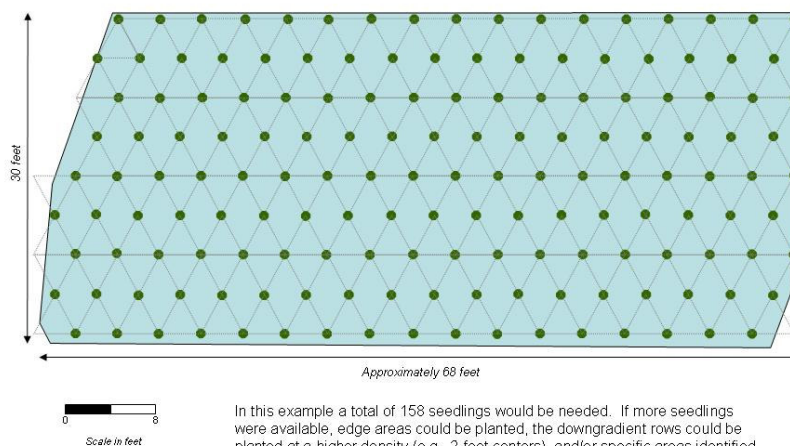
Rooted willow plants (i.e., tubeling) will be planted in selected areas within the river floodplain. The planting of small containerized willows will be focused in areas where more shrub cover is needed and that have groundwater high enough in the summer months to ensure plant survival. A planting tool called a “hoedad” or “dibble” is the best tool for planting tubelings because it facilitates “scalping” (i.e., removing) existing grasses and forbs prior to planting. The removal of the grasses/forbs reduces competitive stress for water and nutrients, thereby increasing the chances of success.

Storage and Planting

Rooted dormant willow stock (10 cubic inch tubelings) will be stored in a cool, moist environment or heeled (i.e., planted) into the soil. During all stages of handling and storage, roots will be kept moist and cool, and free of mold. During storage, the roots will be kept covered at all times, kept moist, and will be protected from extreme temperatures prior to and during planting.

The dormant tubelings will be planted in the fall, before the ground freezes, or in early spring after the frost is out of the ground. Planting tubelings after bud break will be avoided. Tubelings will be planted on 4-ft centers as shown in the schematic below.

EXAMPLE: Idealized Planting Schematic – 4-foot centers

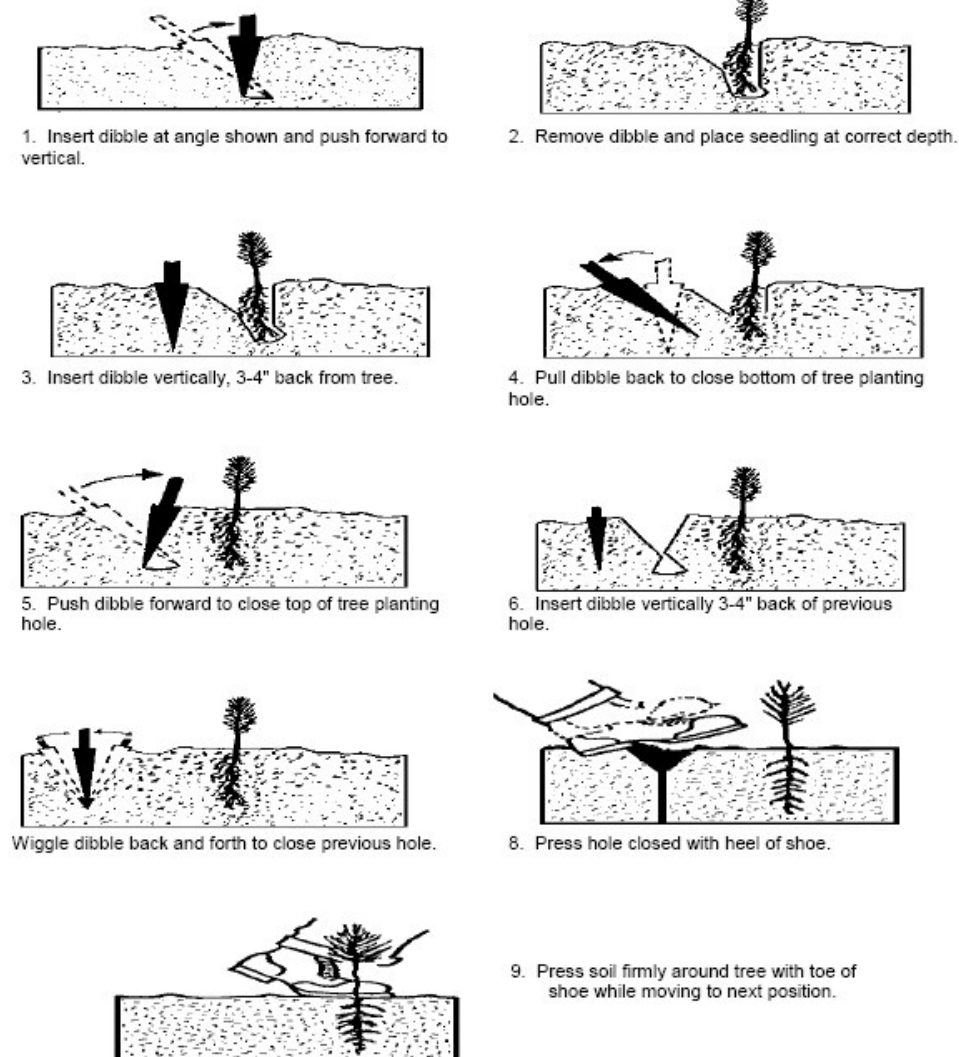


In this example a total of 158 seedlings would be needed. If more seedlings were available, edge areas could be planted, the downgradient rows could be planted at a higher density (e.g., 2-foot centers), and/or specific areas identified in the field could be planted at higher densities.

Using a hoedad, prepare the planting hole by scalping (removing the existing vegetation). Rooted willow stock will be planted in vertical, upright position with the root collars approximately 1/2-inch below the soil surface. *The planting hole must be deep and wide enough to permit roots to spread out and down without J-rooting or L-rooting.* As shown on page 2, the blade of the hoedad (dibble) is swung into the ground at an angle and pushed forward (upright) to create the planting hole. The 10-cubic tubeling is placed at the correct depth (depending upon the root mass (see step 2)). The hoedad is inserted vertically 3 to 4 inches behind the tubelings and pulled back to closed the bottom of the hole and pushed forward to close the top of the hole (see steps 4 and 5). Press the soil firmly around the tubelings with your toe or heel to eliminate air pockets.

The project engineer or vegetation specialist will identify the areas to be planted.

Correct Procedure for Planting Tubelings



(from Stange et al. 2002)